Kennecott
10 East South Temple
P.O. Box 11248
Salt Lake City, Utah 84147
(801) 322-8261

Gregory H. Boyce
Director, Environmental Affairs

July 18, 1986

Kennecott

Mr. Calvin Sudweeks
Director, Bureau of Water Pollution Control
Utah Division of Environmental Health
P. O. Box 45500
Salt Lake City, Utah 84145

SUBJECT: Utah Copper Division Modernization Project

Dear Mr. Sudweeks:

As a portion of the Utah Copper Division Modernization Project, Kennecott intends to construct a slurry pipeline from our new grinding plant near Copperton to our existing Magna and Arthur concentrators. We believe the design information Kennecott has previously submitted to the Bureau demonstrates the pipeline incorporates the best technology available and is very unlikely to fail. The successful operation of the Bonneville slurry pipeline for 20 years with no failures or spills and without the sophisticated failure detection equipment of the Copperton system confirms Kennecott's ability to properly construct and operate this type of facility.

Kennecott acknowledges that this pipeline traverses a recharge area for a major aquifer which is currently a drinking water supply source for Salt Lake County. Repeated pipeline failures might alter the quality of groundwater in this aquifer. Therefore, in the unlikely event of a slurry pipeline failure, Kennecott would provide a complete failure analysis to the Bureau. Kennecott would also reexamine the pipeline system to determine if feasible engineering modifications, including a spill containment system, would be available and applicable to prevent future similar failures. If warranted, feasible and cost effective failure prevention measures would then be implemented upon approval of the Bureau of Water Pollution Control.

Very truly yours,

Gregory H. Boyce

G. H. Boyce

AMT/GHB/mf

cc: R. R. Dimock
V. R. Rao
S. D. Taylor
A. M. Trbovich
J. B. Winter

0020

Dames & Moore

250 East Broadway, Suite 200
Salt Lake City, Utah 84111
(801) 521-9255
Cable address: DAMEMORE

July 8, 1986

JUL 9 1986

A. M. TRBOVICH

Kennecott Corporation
10 East South Temple Street
P. O. Box 11248
Salt Lake City, Utah 84147

Attention: Mr. Al Trbovich

Gentlemen:

Sensitivity Analysis
Ground Water Impacts of Pipeline Failure
Proposed Ore Slurry Pipeline
Western Salt Lake County, Utah
For Kennecott Corporation

This letter presents the results of several sensitivity runs of the ground water model used to evaluate impacts that may result if Kennecott's proposed ore slurry pipeline were to sustain a major failure. These sensitivity runs were done in response to concerns expressed by Mr. Mac Croft of the Utah State Bureau of Water Pollution Control that the permeabilities used in our previous evaluations of this problem presented in our letter report dated June 4, 1986 were too low. The results of these sensitivity runs have been previously discussed in meetings with representatives of Kennecott, Utah State Bureau of Pollution Control (Messrs. Mac Croft and Don Osler) and Dames & Moore on Monday and Tuesday of last week. At the conclusion of Tuesday's meeting Mr. Croft indicated that the results of the sensitivity analysis had resolved his concerns relative to the ground water model; however, he requested a summary of the results and a copy of Dames & Moore's document summarizing peer, federal agency, and State reviews of the ground water model TARGET used in these evaluations. This review is provided as an attachment to this letter. The results of our sensitivity analysis are discussed in the following.

Permeabilities used in developing the models of ground water conditions at the postulated break points were based on site-specific and literature data as well as professional judgment. The permeability and other parameter values selected were believed to be reasonably conservative for the site conditions

along the pipeline route. In response to the State's concerns regarding the permeabilities used in the ground water model, the ground water models were rerun using much higher values. The new values as well as the original values used in the model are summarized on Table 1.

The results of these additional model runs are summarized in Table 2. This summary indicates that the predicted peak concentrations in the modeled wells are significantly lower using the high permeabilities (0.1 versus 0.3 percent for Barneys Creek section and 4. versus 1. percent for the Little Valley Wash section). Peak concentrations were, however, slightly higher at the modeled downgradient boundaries (0.1 versus 0.08 percent at Barneys Creek section, and 1.5 versus 1.0 percent for Harkers Creek section). Overall, the most significant impact resulting from the use of the higher permeabilities is that peak concentrations occurred at much earlier times, thus decreasing the overall duration of the contaminant event.

The distribution of modeled contaminant zones showed essentially the same distribution for both the high and low permeability runs.

In our meeting with the State and Kennecott on Tuesday, it appeared that most of the State's questions regarding our models were answered to the State's satisfaction. Should any further questions develop, please contact us.

Very truly yours,

DAMES & MOORE

George W. Condrat

George W. Condrat
Project Manager

Richard L. Jones

Richard L. Jones
Project Geologist

GWC/RLJ:si
Attachments: Tables 1 and 2
Summary of Ground Water
Model (TARGET) Reviews

TABLE 1

ASSIGNED MODEL PARAMETERS

Parameter	Original Values (Case I)		Sensitivity Run Values (Case II)	
Hydraulic Conductivity (ft/day)				
Bedrock (Zone 1)	0.3 H	0.6 V[a]	3.0 H	0.3 V
Harkers Alluvium (Zone 2)				
Barneys Creek Section	0.6 H	0.3 V	12. H	6.0 V
Harkers Creek	3.0 H	0.3 V	12. H	6.0 V
Shallow Aquifer (Zone 3)	3. H	0.3 V	30. H	3.0 V
Confining Layer (Zone 4)	0.003 H	0.0003 V	0.03 H	0.003 V
Deep Aquifer (Zone 5)	30. H	3. V	30. H	3.0 V
Porosity (all layers) (%)	30		c	
Dispersivity (ft)				
Longitudinal	50		c	
Transverse	10		c	
Natural Areal Recharge (inches/yr)	2.3		c	
Well Pumpage (Copperton & Magna Wells) (gpm)	150		c	
Unsaturated Soil				
Characteristic Curves				
Zones 3 & 5	"typical" sand[b]		c	
	"typical" loam[b]		c	

a H = Horizontal hydraulic conductivity
V = Vertical hydraulic conductivity

b See Van Genuchten and others (1977)

c Same as Case I

Table 2

SUMMARY OF MODEL RESULTS

CONCENTRATIONS OF MODELED CONTAMINANTS*

Time	Barneys Creek Well Case I	Barneys Creek Well Case II	Barneys Creek Downgradient Boundary Case I	Barneys Creek Downgradient Boundary Case II	Harkers Creek Downgradient Boundary Case I	Harkers Creek Downgradient Boundary Case II	Little Valley Wash Well Case I	Little Valley Wash Well Case II
10 days	<.001	<.001	<.001	<.001	<.001	<.001	0.1	<.001
100 days	<.001	<.001	<.001	<.001	<.001	<.001	2.	0.01
1 year	<.001	0.02	<.001	<.001	<.001	<.001	2.	0.06
10 years	<.001	0.03	<.001	<.001	<.001	0.03	4.	1.
50 years	0.31	<.001	<.001	0.03	0.09	1.	4.	1.
100 years	0.3	<.001	<.001	0.1	0.10	0.4	2.0	0.5
1000 years	<.001	<.001	0.08	<.001	0.08	<.001	0.002	<.001
Time at Peak Concentration	80 yrs	15 yrs	900 yrs	100 yrs	140 yrs	40 yrs	4 yrs	25 yrs
Peak Concentration	0.3	0.1	0.08	0.1	1.	1.5	4.	1.

* Concentrations expressed as percent of initial concentration in slurry.
Case I represents assigned model parameters used in our original report (see Table 1).
Case II represents same assigned model parameters used in our original report except for increased permeabilities (see Table 1).

SUMMARY OF
GROUND-WATER MODEL (TARGET) REVIEWS

The purpose of this document is to summarize peer, federal agency and state agency reviews of the TARGET model with a view to clarifying the context and outcome of significant reviews. The objective of most of the reviews documented here was to establish validity of the model/assumptions/data for the site in question. Quite frequently the reviews were undertaken with ensuing public review or litigation in mind. Dames & Moore testing and validation of the TARGET models is described in the model documentation and not considered here.

Attachment 1 provides a list of projects in which ground-water modeling formed a significant portion of the study and elicited separate review. A range of different agencies have been involved, in at least one case an external expert was involved in assisting agency review. In some of the cases listed here additional model calculations were requested to cover a wider range of site conditions, but at no time have the basic tenets of the model remained under question.

Two of the model reviews listed in Attachment 1 are described further in Attachment 2 and 3 (the original letters and reviews excerpted in Attachments 2, 3 and 4 are available for review on request). Attachment 2 contains the text of a letter from the U.S. Geological Survey (USGS) to the Bureau of Land and Minerals Management concerning verification of model predictions for the Anaconda Minerals Jackpile-Paguate Mine, New Mexico. The conclusions of the USGS study "established that the model used by Dames & Moore contained no inconsistencies of a mathematical or programming nature which significantly affected its results".

Attachment 3 covers an EPA review of model documentation, users guides, validation cases and 3D source listing prior to model application at a Superfund site in Baton Rouge, Louisiana. Review of the technical approach proposed at this site was particularly sensitive due to on-going litigation. The conclusions of the review state that "the theory and logic presented appear to be suitable to perform reasonably reliable simulations". In addition, it was recommended that the EPA rely on the TARGET code at the site under question, with the proviso of a comprehensive sampling and monitoring plan.

Attachment 4 consists of the general review comments on the TARGET package provided by Professor Allan Freeze. This review was solicited by Dames & Moore in the interests of refining the model documentation prior to sale of the TARGET models. Freeze's general comments indicate that "the TARGET package is versatile and powerful" while noting that the level of sophistication in the Physical and Mathematical Background chapter may be beyond typical engineers in small consulting firms. The specific comments elaborate on the general comments with reference to portions of the documentation, and have not been reproduced here.

The reviews described here, in combination with model documentation and validation as well as publication of theory and predicted results, provide the basis for background substantiation of model predictions.

ATTACHMENT 1

List of Projects in Which TARGET Predictions Were Reviewed and Accepted by State and Federal Agencies

Client	Date	Version of TARGET	Agency	Notes On Project Status
Amoco, Salt Lake City	5/85	2DU/2DH	EPA, State of Utah	Project Complete, Permit Pending
Anaconda Blue Water	3/81	2DU	NMEID	Project On Hold
Anaconda Minerals	2/84	2DU	USGS, BLM	Modeling Approved, EIS Being Finalized
Chem-Security	7/84	2DU/2DH	EPA	Modeling Complete
Chevron, Salt Lake City	3/85	2DU	EPA, State of Utah	ACL Petition
Federal American Partners	12/80	1DU/2DU/2DH	Wyoming DEQ	Project On Hold
Motorola, Phoenix	12/83	2DH/2DU/3DS/3DU	ADHS, ADWR, EPA	Continuing
Olean/NYSDEC	3/85	3DS	EPA, NYSDH	RI/FS Being Finalized
Petroprocessors, Inc.	6/85	2DU/2DH	EPA (Washington)	Pre-Project Model Approval Was Required
Phelps-Dodge	5/84	2DU/2DH	NMEID	Permit Approved
UMTRAP	82 & 83	2DU	DOE	Status Unknown
Gulf + Western	10/85	2DU	Colorado DOH, EPA	Continuing
Waste Management, Inc.	11/85	2DU	EPA (Ohio)	Model Approved, Project Continuing
Kentucky Avenue/ NYSDEC	11/85	2DH	EPA, NYSDH	Continuing

USER REFERENCES

This section provides brief descriptions of several projects, with references, in which the model and its application came under close scrutiny by the client and/or state or federal agencies or which involved sale of the models discussed in this proposal.

Project:	Remedial Investigation/Feasibility Study
Location:	Phoenix, Arizona
Owner/Client:	Motorola, Inc.
Reference:	Mr. Robert Lee, Motorola (602) 244-3911 Mr. Philip Briggs, Deputy Director, Arizona Dept. of Water Res. (602) 255-1586
Completion Date:	August 1986
Scope of Work:	Modeling was used at an early point in this project to aid in providing guidance and direction for determining the location and screened intervals of monitoring wells. It was recognized that TCE contaminants were occurring as a separate phase fluid and that contaminant movements were driven in part by density differences between the TCE and ground water. A fully three dimensional model accounting for density differences was used to perform sensitivity analyses to determine the influence of recharge, formation geometry and formation hydraulic conductivity. These studies indicated that detailed information on formation geometry was needed in the contaminant source areas. The model was subsequently used to understand the complex existing distribution of contaminants and the mechanisms of transport. This understanding allowed the approximate edges of the plume to be calculated with confirmational field monitoring rather than defining the edge of the plume through exhaustive field studies. The calibrated model will be used in the future to evaluate the effectiveness of alternate remedial action proposals.

Project:	Closure/Post Closure Plans - Remote Hazardous Waste Management Facilities
Location:	Salt Lake City, Utah
Owner/Client:	Amoco Oil Co.
Reference:	Mr. Dan Drumiler, Supt. Of Environmental Control & Safety, Amoco (801) 521-4831 Mr. Felix Flecas, Region VII, EPA (303) 293-1669
Completion Date:	May 1984
Scope of Work:	Modeling was used to predict the existing ground water flow paths and to analyze the effectiveness of selected closure options which included remedial action. Existing flow paths were predicted based on very limited data, to show that man-made canals acted as local hydrogeologic boundaries. Using the predictions, piezometers were drilled to provide field verification. The predictions were within 10% of the observed field values. Subsequently, the efficiency of collection ditches with slurry walls was evaluated as a function of collection ditch depth. The volume of flow to the ditches was calculated and a shallow ditch was found to be as effective as deeper ditches, at lower cost.

Project:	Alternate Concentration Limits Petition
Location:	Salt Lake City, Utah
Owner/Client:	Chevron USA, Inc.
Reference:	Mr. Mike Hannigan, Region 8, EPA (303) 293-1667
Completion Date:	March 1985
Scope of Work:	Modeling was used for several purposes to demonstrate the appropriateness of alternate concentration limits. It was used to accurately calculate the volume of ground water discharging to a receiving surface water canal. The ACL petition hinged, in part, on the dilution ratio of surface water to ground water flow rates. Modeling was also used to establish the maximum theore-

tical extent of contaminant transport under a variety of hypothetical situations including high rate pumping of an underlying aquifer, long term wet meterological conditions and long term dry meterological conditions.

Project:	Ground Water and Receptor Analysis Modeling
Location:	Baton Rouge, Louisiana
Owner/Client:	NPC Services Inc.
References:	Dr. Larry Bone, NPC Services Phone: (504) 292-6591 Mr. Peter Ornstein, Hydrogeologist, Office of Solid Waste and Emergency Response, EPA Phone: (202) 382-2063
Completion Date:	Model review complete, report review still underway.
Scope of Work:	Dames & Moore conducted ground-water mathematical modeling analyses at two sites to investigate the potential for contamination of multiple aquifers and to aid in design of a trigger monitoring network. Unusual site-specific features included seasonally-varying boundary conditions associated with the nearby Mississippi River.

Project:	Simulation of Recovery from Mine Dewatering
Location:	Jackpile-Paguate Uranium Mine, New Mexico
Owner/Client:	Anaconda Minerals, Inc.
Reference:	Mike Kernodle, Hydrologist, New Mexico District Office, U.S. Geological Survey Phone: (505) 766-1593 U.S.G.S Report "Results of Simulations using a U.S. Geological Survey generic two-dimensional groundwater flow model to process input data from the Dames & Moore groundwater flow model of the Jackpile-Paguate Uranium Mine, New Mexico," August 12, 1984.

Completion Date:	August 1984
Scope of Work:	The U.S. Bureau of Land Management, the U.S. Bureau of Indian Affairs, and the Pueblo of Laguna are in the process of assessing proposed reclamation measures for the Jackpile-Paguate uranium mine in west-central New Mexico. The operating company, Anaconda Minerals, retained Dames & Moore to model and project post-reclamation water levels in the pits. The simulations included pre-mining steady state analysis of flow in the Jackpile and Rio Paguate/Rio Moquino alluvial aquifers, analysis of post-reclamation water-level recovery within uniform backfill material, and analysis of water-level recovery with backfill material of variable properties. At the request of the Land and Minerals Management the U.S.G.S. undertook identical calculations with the Survey Model and found that the Dames & Moore model exhibited "no inconsistencies of a mathematical or programming nature which significantly affects its results."

Project:	Hydrologic Investigations in Support of Groundwater Discharge Plan.
Location:	Hidalgo County, Southwestern New Mexico
Owner/Client:	Phelps-Dodge Corporation
References:	Mr. Kent Bostick, Groundwater Hydrologist, State of New Mexico, Environmental Improvement Division Phone: (505) 984-0020, Ext. 508
Completion Date:	November 1983, August 1984
Scope of Work:	Dames & Moore conducted, among other hydrologic investigations, predictions of the migration of contaminants from an evaporation pond in order to evaluate the effect of evaporation pond operation on water quality in the nearby Playas Lake. The lined but leaky evaporation pond is used to receive liquid effluent of high TDS from the smelter. A series of model simulations were used to: o Establish the depth to which contaminants are likely to migrate.

- Confirm estimated infiltration rates calculated on the basis of an approximate water balance.
- Calibrate uncertain model parameters through comparison of observed concentrations with those predicted.
- Predict the concentration levels which will occur in the vicinity of Playas Lake in the future.

The predicted extent and depth of contamination was corroborated by geophysical testing undertaken by the client.

Project:	Simulation of Chemical Seepage from Power Plant Solid Waste
Location:	Not applicable
Owner/Client:	Electric Research Institute/Acurex Corporation
Reference:	Dr. Larry Waterland, Program Manager, Acurex Corporation Phone: (415) 964-3200, Ext. 3618
Completion Date:	August 1981, February 1983, October 1984
Scope of Work:	The three projects involved mathematical modeling analyses of the migration of selected chemical species in the waste, through the liner (if present), in the unsaturated zone, and through the saturated aquifer beneath and adjacent to lined and unlined sludge landfills and ash ponds. In one instance ambient, long-term concentrations in a nearby river, resulting from the predicted pond overflow, were also analyzed. The overall purpose of the studies was to predict the likely concentrations of 13 chemical species in the groundwater, as a result of the 30-year operation of waste impoundments of various configurations, at two hypothetical drinking-water wells 1.0 and 2.5 km downgradient of facilities. The results of these studies were used in a risk evaluation of power plant integrated control configurations.

Project:	Technology Transfer (sale), TARGET 3D Ground Water Model
Location:	Phoenix, Arizona
Owner/Client:	Arizona Department of Water Resources
Reference:	Mr. Philip Briggs, Deputy Director, ADWR (602) 255-1586
Completion Date:	August 1986
Scope of Work:	Installation of codes and plotting programs on client's computer and 3 day training seminar for ADWR project mangers and staff in code use. ADWR is planning on using the codes for the evaluation of TCE movements at 2 superfund sites.

Project:	Technology Transfer, TARGET Ground-Water Models
Location:	Tokyo, Japan
Owner/Client:	Chiyoda Chemical Engineering Company
Reference:	Mr. Yanagawa, Chiyoda Dames & Moore Phone: 81-3-454-4741
Completion Date:	Installation complete, training yet to be undertaken.
Scope of Work:	Transfer of the five models involved the following tasks: 1. Delivery of five TARGET codes and documentation. 2. Assistance with conversion of codes from VAX versions to IBM versions. 3. Training seminar.

Project:	Transfer of three TARGET models
Location:	Horsham, England
Owner/Client:	Electrowatt Engineering Services (UK) Ltd.
Reference:	Mr. Stephen D. Lympany Phone: 44-1-403-50131
Completion Date:	July 1985
Scope of Work:	Delivery of three TARGET codes and documentation.

ATTACHMENT 2

Memorandum From

United States Department of Interior

Geological Survey, Reston, VA 22092

(Text of Letter Reproduced In Full Below)

August 23, 1984

Memorandum

To: Assistant Secretary -- Land and Minerals Management

Through: Assistant Secretary -- Water and Science

From: Director, Geological Survey

Subject: PUBLICATIONS- Report "Results of simulations using a U.S. Geological Survey generic two-dimensional ground-water-flow model to process input data from the Dames & Moore ground-water-flow model of the Jackpile-Paguate Uranium Mine, New Mexico"

In accordance with the agreement reached at the meeting of May 29, 1984, between yourself, Bureau of Land Management (BLM) Assistant Director Sokoloski, other representatives of BLM, and Philip Cohen, Gordon Bennett, and Roger Wolff of the Water Resource Division, U.S. Geological Survey (USGS), we are pleased to provide the accompanying two copies of the subject report.

In the work summarized in this report, USGS hydrologists of the New Mexico District office carried out a number of numerical simulations of the ground-water-flow system in the vicinity of the Jackpile mine. The simulations were performed using a standard USGS generic model for two-dimensional ground-water flow; they employed hydrologic parameters which in some cases were identical to those used in an analysis by Dames & Moore, Inc., and in some cases were systematically varied from those values.

In all, 14 simulations were carried out by USGS hydrologists. Initially, four simulations were run corresponding to Case 1 of the Dames & Moore analysis, which addressed the pre-mining steady-state condition of the aquifer. These four simulations differed from one another in the subdivision of the model mesh, in the way a particular aquifer outcrop was simulated, and in the way two streams, the Rio Paguate and Rio Moquino, were simulated; the hydraulic conductivity and recharge values used in all four of these simulations were identical to those used by Dames & Moore. Next, two simulations were carried out corresponding to Case 3 of the Dames & Moore analysis, which addressed the final post-reclamation condition, subject to the assumption that no low-permeability barrier would be emplaced in the North Paguate pit during reclamation.

These two simulations differed from one another only in the way the Rio Paguate and Rio Moquino were represented; the hydraulic conductivity and recharge values were identical to those of Dames & Moore. Finally, eight simulations were carried out corresponding to Case 3.5 of the Dames & Moore analysis, which again addressed the final post-reclamation condition, but with the assumption that a low-permeability barrier would be emplaced in the North Paguate pit during reclamation. Within this group, the first two simulations differed from each other in the way the streams were represented, but again, the hydraulic conductivity and recharge values used by Dames & Moore were retained. The final six simulations of this group, on the other hand, in-corporated various combinations of recharge and hydraulic conductivity which differed from those used by Dames & Moore. The variation in recharge consisted of an increase from 0.12 inches to 0.24 inches per year over a relatively small fraction of the modeled area. The changes in hydraulic conductivity involved uniform halving and doubling of the aquifer conductivity, and uniform halving and doubling of the conductivity of the backfill material in the reclaimed mine pits.

The USGS work established that the model used by Dames & Moore contained no inconsistencies of a mathematical or programming nature which significantly affected its results. The analysis further demonstrated that the changes in the method of simulating the outcrop and the streams produced significant water level differences only in the immediate vicinity of those features. Variation in recharge and hydraulic conductivity, on the other hand, caused significant water level differences within the reclaimed mine pits. In one simulation, in which the hydraulic conductivities of the aquifer and the backfill were doubled while the recharge values used by Dames & Moore were unchanged, the USGS results indicated lower post-reclamation ground-water levels in the Jackpile and South Paguate pits, but higher levels in the North Paguate pit. In the five other simulations in which parameters were varied, the USGS results indicated final ground water levels in the reclaimed pits that were higher by at least 20 feet, and commonly by as much as 50 feet, than those computed by Dames & Moore. These results illustrate the sensitivity of computed water levels to the assumed parameters, but do not in any way either corroborate or dispute the parameter values assumed by Dames & Moore. We point out again that to address this latter question a full hydrologic investigation, requiring at least 18 months' time, would be required.

ATTACHMENT 3

Memorandum From

United States Environmental Protection Agency

Washington, D.C. 20460

(Text of Covering Memorandum and Conclusions
Reproduced in Full Below)

May 17, 1985

MEMORANDUM

SUBJECT: Review of TARGET Code for use at Petro Processors Site

FROM: Peter M. Ornstein, Hydrogeologist
Physical Sciences Section, OWPE (WH-527)

THRU: Rob Clemens, Acting Chief
Physical Sciences Section, OWPE

TO: Tony Gardner
Region VI

Attached please find my review of Dames & Moore's TARGET computer code. Based on my review, I recommend that EPA accept the use of TARGET at the Petro Processors Site provided that a comprehensive monitoring and sampling plan is implemented. The plan should provide for monitoring contaminant levels in and around the predicted plume in the 40 foot zone to assist in code calibration and also provide for monitoring the 400 foot aquifer in selected locations to assure trigger level credibility.

In light of this recommendation, the Phase 2 review of TARGET does not seem appropriate. At such time as the agency has determined what peer review criteria and procedures will be employed for the selection and use of groundwater models, this and other model codes will, in all likelihood, be evaluated in greater detail on a generic basis.

Please call me at (FTS or 202) 382-2063 if you have any questions or comments.

CONCLUSION

As the purpose of this review is to recommend whether or not EPA may rely upon TARGET to produce reasonably reliable results at the Petro Processor's site, portions of the documentation not relevant to this purpose were not critically reviewed. In addition, any confidence in TARGET expressed herein must be qualified since the reviewer did not run the code and therefore did not have

the opportunity to test or stress the code. Overall confidence in the TARGET code would be substantially improved if the code were in the public domain and used by others within the technical community.

In summary, TARGET employs a non-traditional approach to modeling contaminant transport in ground water by use of its guess and correct algorithm. Given the limited scope of this review, the theory and logic presented appear to be suitable to perform reasonably reliable simulations. No inherent deficiencies either in the guess and correct algorithm or in the way the hydrodynamics and mass transport have been treated are apparent.

It is recommended that EPA rely upon the TARGET code at the Petro Processor's Site. It cannot be overemphasized that use of TARGET must be performed in conjunction with a comprehensive sampling and monitoring plan. The monitoring and sampling is necessary to provide a "safety net" to counter the uncertainty associated with the site's complex hydrogeology as well as uncertainty associated with modeling the site (i.e., quality of data, applicability of generic assumptions to the site, etc.). Since the intended use of TARGET is to establish trigger levels in the 40 foot zone to protect the 400 foot aquifer, both zones should be monitored to enhance confidence in the predicted levels as well as aid in further field calibration and verification of the model.

To reiterate, the scope of this review focused on TARGET's use for a specific purpose at the Petro Processor's site. Until such time as the code has been peer reviewed and tested in the professional community and available in the public domain, evaluation of site by site applications is recommended.

ATTACHMENT 4

Letter From

R. Allan Freeze, Ph.D., P.Eng.

(Text of General Comments Reproduced
in Full Below)

July 10, 1985

Dr. D. A. Stephenson
Dames & Moore
3737 N. 7th Street, Suite 121
Phoenix, Arizona
U.S.A. 85014

Dear Dave:

In response to your letter of June 11, 1985, I reviewed the Dames & Moore TARGET package, giving special consideration to the suitability of the documentation for outside-the-firm release. I have divided my comments into general comments and specific comments.

GENERAL COMMENTS

1. It is clear to me that the TARGET package is a versatile and powerful set of computer programs for the mathematical modeling of groundwater flow and solute transport. The mathematical foundations are strong and the numerical methodology clever and efficient. It is clear that the authors of the program and the documentation are working from a strong technical base.

2. The writing style throughout the report is very clear. I will have some comments about the level and order of presentation, but I must emphasize that the current presentation of each topic, both in their descriptive and mathematical contexts, is very well done.

3. The major area of concern that I can identify lies in the level of sophistication in the chapter on the Physical and Mathematical Background of the models. This chapter uses a very sophisticated mathematical framework and a very advanced notation. As a research scientist in this field I find it compact and elegant, but my experience in dealing with small consulting firms who may provide a primary market for TARGET would lead me to question whether engineers from such firms would be at home with this level of presentation. One must ask to whom this chapter is directed. If it is directed to reviewers such as myself as a kind of base document that lays out the mathematical foundations of the programs for those few who may wish to follow it up, then the current presentation may be suitable. If, on the

other hand, it is intended as a kind of textbook to accompany training sessions for consulting engineers from smaller companies, then I believe it needs to be expanded and the order changed somewhat in order to bring it into line with the backgrounds that such "students" will have. Several of the Specific Comments pertain to this issue, but the more general suggestions are as follows:

(a) The Introduction should be expanded to include more complete descriptions of the types of boundary-value problems that the programs can handle (and the engineering problems to which they apply). It should include clear definitions of such concepts as steady-state and transient flow, unsaturated and saturated pressure heads, homogeneity and anisotrophy, etc.

(b) Section 2-0 on Physical Mechanisms and Chemical Processes should include detailed positive statements of the capabilities of the models with respect to groundwater flow and solute transport. In the current write-up the basic assumptions of Section 2-1-1 hit the reader without lead in or warning. Some of them are quite sophisticated and required a detailed understanding of the equations of groundwater flow. I would be inclined to save this list until after the primary development of Section 3-0.

(c) The references provided in the Introduction are a bit obscure. I would refer to the available textbooks by Wang and Anderson, Pinder and Gray, Remson et al, and to the AGU monograph by Bredehoeft et al and the NWWA monograph by Mercer and Faust.

(d) Much of the descriptive material is too terse. Two examples: (i) Section 2-2 on Solute Transport ought to summarize all the mechanisms of transport noting which ones are included and which ones are not; (ii) The discussion of seepage faces in the 2nd paragraph from the bottom of page 16 does not hint at the complexities associated with their simulation (iterative positioning of the exit point, problems associated with multiple seepage faces, etc.).

(e) There are many examples in the Specific Comment of cases where the readers first encounter with a concept or notation occurs in the midst of some other explanations. Examples: (i) on p. 26 just below Eqn. (4-38) the reader is first informed that the numerical solution is iterative; (ii) The Peclet number is introduced for the first time on page 3-1 in the Validation Chapter. In all cases, introductory material should have appeared earlier so that the reader is not taken by surprise.

(f) I would prefer to see variables defined at the point of first encounter as well as in the notation list. It is difficult for the reader to switch back and forth from the text to the list and to locate the particular symbol on the list.

4. In the Introduction it is stated that there are 5 models in the TARGET family, but there are 18 possible contaminations of the properties listed there. The 5 models should be identified clearly and examples of their use described. Model TARGET 2DH does not figure anywhere in the Background chapter or the User's Guides, but it appears in the first two validation cases.

5. The User's Guide to TARGET 2DU and TARGET 3DS are clearly done and should prove easy to follow by prospective clients. The Specific Comments note a few places where clarification is needed. I note, however, that a list clearly relating the computer acronyms to their mathematical notation in the Background chapter would be useful.

6. The chapter on the Summary of Validation Cases is clear and convincing. The only apparent capability of the TARGET family that is not fully validated is a case that involves solute transport in the unsaturated zone. If such a validation is available, it would make a worthwhile addition.